MECHANICAL AND THERMAL PROPERTIES OF MONTMORILLONITE FILLED DATE PALM LEAF FIBER REINFORCED RECYCLED POLYETHYLENE TEREPHTHALATE NANOCOMPOSITES

ALIREZA DEHGHANI

UNIVERSITI TEKNOLOGI MALAYSIA

MECHANICAL AND THERMAL PROPERTIES OF MONTMORILLONITE FILLED DATE PALM LEAF FIBER REINFORCED RECYCLED POLYETHYLENE TEREPHTHALATE NANOCOMPOSITES

ALIREZA DEHGHANI

A thesis submitted in fulfilment of the
requirements for the award of the degree of
Masters of Science (Polymer Technology)

Faculty of Chemical Engineering
Universiti Teknologi Malaysia

OCT 2012

You will forgive me, my dear father, if I set your name, so dear to me, at the head of an insignificant brochure. I am too impatient to await another opportunity of giving you a small proof of my love.

I want to dedicate this thesis to my precious wife, Sara. Without her help and encouragement it simply never would have been.

ACKNOWLEDGEMENT

First and foremost, I would like to express my heartfelt gratitude to my supervisor, Assoc. Professor Dr. Mat Uzir Wahit, for his ever-lasting enthusiasm, encouragement, excellent advice and great concern to my work. A sincere thanks is accorded to my co-supervisor, Prof. Dr. Azman Hassan for his guidance, suggestions, motivation and encouraging advices.

I also wish to express my appreciation to all the lecturers in the Department of Polymer Engineering, the staffs in Malaysian Institute of Nuclear Technologies (MINT) for their help and support in my research. A heartfelt line of appreciation to all the technicians and my lab mates of Enhanced Polymers Research Group (EnPRO) for creating a friendly and enjoyable working environment. Besides, I would like to thank Dr. Mariam A Al Maadeed and Qatar university, Department of Materials and Science for generous financial funding throughout my studies. Last but not least, I wish to extend my deep appreciation to my beloved mother, mother and father in law, my brothers and my sisters in law, who have always encouraged and provided me with moral support in completing this thesis.

ABSTRACT

Date palm leaf fiber (DPLF) reinforced recycled poly(ethylene terephthalate) (PETr) nanocomposites containing montmorillonite (MMT) were prepared by melt extrusion using a counter rotating twin-screw extruder followed by injection molding. The influence of the DPLF and MMT along with 10 phr of SEBS-g-MA as compatibilizer on the mechanical and thermal properties of the PETr matrix was evaluated separately, through their individual contributions. The effect of various DPLF additions at from 5 to 15 wt% and the incorporation of 1, 3 and 5 phr of MMT were investigated. Scanning electron microscopy (SEM) was used to investigate the phase morphology and study the adhesion between the matrix and DPLF fibers while the dynamic mechanical properties were studied via dynamic mechanical analysis (DMA). The thermal properties were determined using thermogravimetric analysis (TGA) and differential scanning calorimetry (DSC). The results showed that blending SEBS-g-MA with PETr matrix significantly increased the toughness at the expense of stiffness of the blend. The incorporation of DPLF resulted in enhancements in tensile and flexural strength of the composites. However, a decrease in the Young's and flexural moduli was recorded. Fiber additions also improved the impact strength of the composites and an increase in the area under the stress-strain curve was observed. SEM revealed a strong interfacial bonding between the matrix and fibers, and a homogenous one phase system, indicating strong interactions between the PETr matrix and SEBS-g-MA. The DSC results showed that the crystallization process was enhanced through the incorporation of DPLF fibers, and a higher degree of crystallinity was observed as compared to PETr. However, TGAshowed that, fiber addition lowered the thermal stability of the composites. The incorporation of MMT resulted in a significant increase in the stiffness of the nanocomposites and 58% increment was observed in the flexural modulus was recorded. The addition of nanoparticles also increased the degree of crystallinity for 1 and 3 phr of nanoclay addition. Thermal stability enhancements were observed for all nanocomposite formulations. The results pointed to a successful development of a hybrid nancomposite from recycled PET and natural fiber with the potentialof various outdoor applications.

ABSTRAK

Gentian daun pokok kurma (GDPK) diperkukuh dengan nanokomposit poli(etilena terephthalate) (PETr) yang dikitar semula terisi montmorillonit (MMT) telah disediakan melalui penyemperitan leburan menggunakan penyemperitan skru berkembar berlawanan arah dan diikuti dengan pengacuan suntikan. Sifat-sifat mekanikal dan terma terhadap GDPK, MMT bersama 10 phr stirena-etilina-butadiena-stirena tercangkuk malik anhidrida (SEBS-g-MA) yang digunakan sebagai penyerasi ke atas PETr matrik telah di kaji secara berasingan melalui ciri-ciri bagi setiap bahan. Kesan variasi penambahan GDPK dari 5 sehingga 15% berat dan penambahan MMT sebanyak 1, 3 dan 5 phr terhadap campuran telah dikaji. Mikroskop imbasan electron (SEM) telah digunakan untuk mengkaji fasa morfologi permukaan dan interaksi di antara matrik dan gentian GDPK manakala sifat dinamik mekanikal telah dikaji melalui analisis dinamik mekanikal (DMA). Sifat terma pula telah ditentukan menggunakan analisa thermogravimetri (TGA) dan kalorimeter pembezaan imbasan (DSC). Keputusan yang diperolehi menunjukkan bahawa pengadunan SEBS-g-MA bersama PETr matrik telah meningkatkan keliatan tetapi menyebabkan penurunan kekakuan campuran tersebut. Campuran GDPK telah meningkatkan kekuatan regangan dan lenturan komposit manakala modulus Young dan modulus lenturan menunjukkan penurunan. Penambahan gentian telah meningkatkan kekuatan hentaman komposit dan penambahan lengkuk tegasan-terikan telah diperhatikan. SEM telah menunjukkan bahawa terdapat ikatan antara permukaan yang kuat di antara matrik dan gentian, dan satu fasa sistem yg sekata yang membuktikan bahawa interaksi yang kuat diantara PETr matrik dan SEBS-g-MA. Keputusan DSC menunjukkan bahawa proses penghabluran telah meningkat melalui penambahan gentian GDPK dan penambahan darjah penghabluran telah diperhatikan berbanding PETr. Bagaimanapun, keputusan TGA menunjukkan dengan penambahan gentian di dalam komposit telah menurunkan kestabilan terma komposit. Penambahan MMT ke dalam komposit telah meningkatkan kekakuan dengan ketara dan peningkatan sebanyak 58% bagi modulus lenturan telah diperhatikan. Penambahan nanopartikel telah meningkatkan darjah penghabluran bagi 1 dan 3 phr dengan penambahan nanotanah liat. Peningkatan kestabilan terma telah diperhatikan bagi kesemua formulasi nanokomposit.